United States Military Academy
West Point, New York 10996

U.S. Army Delayed Entry Program Optimization Model

OPERATIONS RESEARCH CENTER OF EXCELLENCE
TECHNICAL REPORT No. DSE-TR-0428
DTIC #: ADAXXXXX

Lead Analyst
Major Jason A. Wolter, MEM
Analyst, Operations Research Center

Senior Investigator
Lieutenant Colonel Michael J. Kwinn, Jr., Ph.D
Associate Professor, Department of Systems Engineering

Editor
Lieutenant Colonel John B. Halstead, Ph.D
Assistant Professor, Department of Systems Engineering

Directed by
Lieutenant Colonel Michael J. Kwinn, Jr., Ph.D.
Director, Operations Research Center of Excellence

Approved by
Colonel Michael L. McGinnis, Ph.D.
Professor and Head, Department of Systems Engineering

August 2004

Distribution A: Approved for public release; distribution is unlimited.

U.S. Army Delayed Entry Program Optimization Model

Lead Analyst
Major Jason A. Wolter, MEM
Analyst, Operations Research Center

Senior Investigator
Lieutenant Colonel Michael J. Kwinn, Jr., Ph.D
Associate Professor, Department of Systems Engineering

Editor
Lieutenant Colonel John B. Halstead, Ph.D
Assistant Professor, Department of Systems Engineering

Directed by
Lieutenant Colonel Michael J. Kwinn, Jr., Ph.D.
Director, Operations Research Center of Excellence

OPERATIONS RESEARCH CENTER OF EXCELLENCE
TECHNICAL REPORT No. DSE-TR-04-03
DTIC #: ADAXXXXX

Approved by
Colonel Michael L. McGinnis, Ph.D.
Professor and Head, Department of Systems Engineering

August 2004

Distribution A: Approved for public release; distribution is unlimited

Abstract

U.S. Army Recruiting Command (USAREC) requires a robust and predictive system that optimizes their monthly and annual percentage of recruits in the Delayed Entry Program (DEP). This optimization system must also consider the dynamic nature of "In and For" recruits, those recruits who are contracted and accessed in the same month. The DEP is a direct reflection of current economic factors (i.e., unemployment), eligible youth, DoD marketing/advertising efforts, and the resources available to recruiters. This research integrates previous research concepts to help build a predictive management system that will assist in minimizing the impacts of DEP loss. Additionally, this research examined the use of "In and For"·contracts given historic research and new policy changes. Ultimately, this research allows USAREC to increase efficiency in meeting accession requirements, and provide a tactical tool for planning.

About the Authors

Major Jason A. Wolter is an Analyst in the Operations Research Center of Excellence in the Department of Systems Engineering at the United States Military Academy, West Point. He has a B.S. degree from USMA, and a M.S. from Northwestern University. Major Wolter can be contacted at jason.wolter@us.army.mil.

Lieutenant Colonel Michael J. Kwinn, Jr. is an Associate Professor in the Department of Systems Engineering and Director of the Operations Research Center of Excellence at the United States Military Academy, West Point. He has a B.S. Degree from USMA, M.S. degree in Systems and Industrial Engineering from the University of Arizona and a Ph.D. in Management Science and Information Systems from the University of Texas, Austin. His research interests include operational assessment methodology, efficiency analysis, recruiting analysis especially marketing effects and capability analysis and modeling. Lieutenant Colonel Kwinn may be contacted at michael.kwinn@usma.edu

Acknowledgements

Table of Contents

List of Figures

List of Tables

1   Introduction

The United States Army Recruiting Command (USAREC) is responsible for recruiting and transitioning high quality civilians to Army enlisted applicants who will ship to basic combat training. To better support the growing and transforming Army, USAREC continuously examines best business practices to improve recruiting efficiency and quality. This research's focus is identifying proper inventory levels for new enlisted applicants through the accession process.

Traditionally, recruiters contact young men and women and communicate Army opportunities to qualified candidates. The Army establishes a contract with those eligible applicants whom volunteer to serve in the Army. From the time the applicant signs the contract until the applicant ships to basic combat training, the applicant is within the Delayed Entry Program (DEP). The DEP can last one day to times exceeding twelve months. This research examines the appropriate number of new recruits that should enter basic combat training within the same month they are contracted. These recruits are labeled "In and For" recruits and present a particular challenge to USAREC. The second area of our research is properly identifying the appropriate percentage of recruits contracted in the current year for accession in the following year, known as entry DEP (EDEP). This surplus of recruits helps reduce recruiting seasonality and achieve annual recruiting missions.

The remainder of the report is structured into five chapters. Chapter 2 is a brief discussion of Army recruiting concepts and USAREC organization. Chapter 3 provides the research's problem definition. Chapter 4 focuses on managing the "In and For" recruits with recommendations for changing policy. Chapter 5 addresses the issue of optimizing the EDEP to include: objectives and metrics for a model, alternative solution methods, and detailed models.   Lastly, Chapter 6 provides the conclusion with recommendations and areas of future research for EDEP analysis.

2 Recruiting Concepts

2.1 Historical Overview of Recruiting Command and DEP

Since the creation of an all voluntary Army, Recruiting Command's mission has been recruiting eligible civilians for service in the Army. In its infancy, Army recruiting faced many challenges. Recruiting became successful in 1979 when the USAREC Commanding General, General Maxwell Thurman, provided sophisticated managerial techniques, redefined the mission, and focused staff efforts. So visionary were General Thurman's initiatives, USAREC continues using many of his policies and procedures. The Delayed Entry Program (DEP) is one of the current managerial techniques employed by the Army to fulfill the annual recruiting mission. The DEP was introduced in 1960 as a management tool to schedule the entry of individuals into training classes. The DEP facilitates applicant choice by giving them flexibility when signing a contract. By choosing their future training day, applicants are also able to choose a specific Military Occupational Specialties (MOS). In return, the Army obtains a personnel surplus to flow into the training bases. Accessions and Recruiting Command extensively use the DEP for smoothing the seasonal recruiting fluctuations and achieving steady and efficient use of all training facilities.

2.2 USAREC Organization

Recruiting Command Headquarters is located at Fort Knox, Kentucky where, under the direction of the Commanding General, the organization coordinates and supports the recruiting efforts of the U.S. Army. The command consists of five recruiting brigades, each responsible for a separate geographical region within the continental United States and OCONUS (Figure 1). Each brigade is a collection of battalions, companies and individual recruiter stations, which produce sufficient enlistment contracts to meet the Army's annual accession mission. The organization, on average, consists of nearly 1600 recruiting stations containing 7300 recruiters across the United States and overseas.
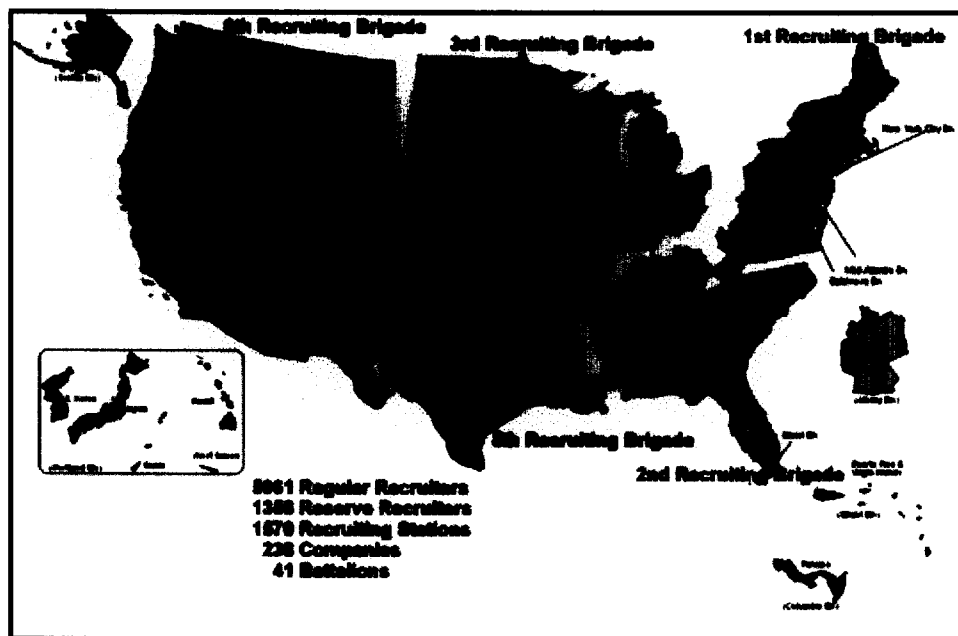
Figure 1, Recruiting Command Organizational Map (G2 USAAC)

2.3 Mission Process

2.3.1 Department of the Army

The Army G1, who is responsible for all Army personnel matters, establishes the annual accession mission. This accession mission is a forecasted personnel assessment of the required strength to support the Army. It includes attrition projections (DEP loss, training losses, re-enlistments, and other attrition) along with total manpower requirements to predict the Army's mission. The G1 annual mission, given to USAREC, specifies the number and attributes required. The Army typically categorizes applicants with four attributes:

- Service History: prior service record (PS) or no prior service (NPS)
- Education level: High school diploma graduates (HSDG) or no high school diploma
- Armed Forces Qualification Test Score (AFQT): test score I-IIIA or below IIIA
- Gender

The G1 also includes projections for the next year total accession mission and the required size of the EDEP, which facilitates that mission. The EDEP represents the number of contracts required in DEP at the end of a fiscal year. The percentage is generally set at 35% of the expected contract mission for the following year. The 35% planning percentage is based on analysis provided in Appendix C. This analysis examined recruiting years 1986 through 2002 and concluded the Army met its recruiting mission in years when the EDEP was 35% or more. The analysis is summarized by the historical recruiting chart shown in Figure 2. The figure plots the EDEP against a fiscal year. The comments explain mission challenges in relationship with to the EDEP percentage. Challenges were either failing to meet mission or requiring extraordinary measures to meet mission.

DEP

*Information Paper: "Army Entry Delayed Entry Program (DEP) Goal"
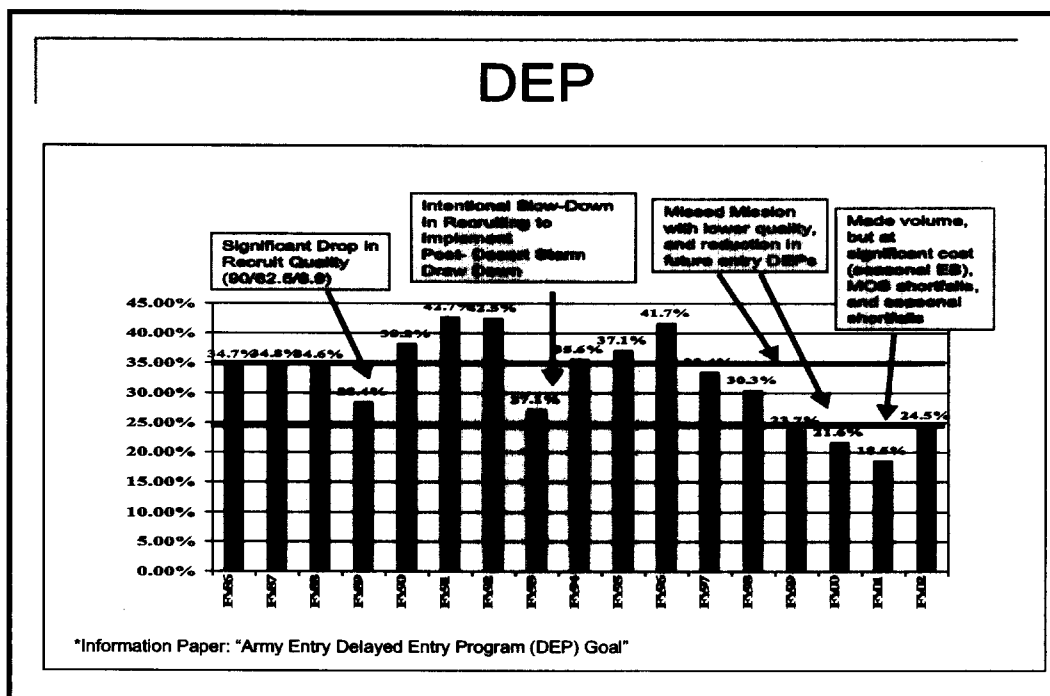
Figure 2, Summary Analysis of the Army 35% EDEP (G1 DA, MAJ Jessup, Appendix C)

The inventory maintenance of the DEP offers distinct advantages to USAREC in smoothing the flow of recruits to training seats, but it also has drawbacks. These advantages and disadvantages are highlighted in Figure 3.

4

Delayed Entry Program

ADVANTAGES	DISADVANTAGES
1. Sources of referrals 2. Less first-term attrition due to more realistic expectations. 3. Smoothing of recruiting efforts 4. Long range planning tool to hedge against seasonal and economic changes or other unpredictable events (ex. Sept. 11) 5. Relief from direct shipment pressure for next month and enables prospecting for higher quality recruits	1. Liaisons between recruiter and DEPers draw from recruiter's time for other activities. 2 Longer time in DEP equates to higher DEP loss 3 May lack sufficient direct ship slots to meet school requirements 4 Equity problem related to differences in DEP size per recruiter

Source: Morey, R. (1987) *Impacts of Size, Composition, and Compactness of the Delayed Entry Pool*. Navy Manpower, personnel, and Training R&D program of the Chief of Naval Research.

Figure 3, DEP Advantages and Disadvantages [18]

2.3.2 USAREC

Recruiting market and mission analysts are responsible for recommending the recruiter distribution and recruiting mission (respectively) across the organization, given the DA accession mission. The analysts specify both the number of required quarterly contracts and the type of contract. Recruiting Command developed mission boxes to classify new contracts for the purpose of monitoring the type of contracts recruited during the quarter and insuring DA mission attribute goals are met. These boxes use four categories to differentiate applicants: service history, education level, AFQT score, and gender (Figure 4).

To efficiently and effectively assign the brigades their mission, analysts use the Recruiter Allocation Model (RAM). The RAM model was developed in January 2001 and is continually updated. The model uses six metrics to develop the expected number of contracts from each zip code region. The metrics used include: number of qualified military applicants (QMA), number of two year college candidates, number of four year college candidates, number of high school graduates, number of high school seniors, and

5

potential. Potential is measured by calculating a nationwide segment penetration rate and multiplying that rate against the segment size in each zip code. The USAREC CG provides weighting of these metrics based on his experience, expectations for the future, and the current market. This accession requirement is distributed by quarters and months to the brigades based on the historic seasonal flow of recruits and the expectation of DEP losses. An example G1 accession mission is represented by Figure 5. This mission can frequently change and its dynamic nature is one of the many difficulties in achieving optimized and efficient recruiting.

MISSION BOXES:

GMA	SMA	PSA	GFB	SFB
GMB	SMB	PS4	GF4	HFT
GM4	HMT	GFA	SFA	PSB

LEGEND

HIGH SCHOOL EDUCATION
G = GRADUATE   N = NON-GRADUATE
S = SENIOR   H = GENERAL EQUIVALENCY DIPLOMA

SERVICE HISTORY
PS = PRIOR SERVICE   NPS= NON-PRIOR SERVICE

GENDER
M = MALE   F = FEMALE

AFQT SCORE
A = 50TH PERCENTILE OR BETTER
B = BETWEEN 31ST AND 49TH PERCENTILE
4 = BETWEEN 26TH AND 30TH PERCENTILE

Figure 4, Accession and Recruiting Command Mission Boxes (G2 USAAC)

DA Accession mission for 2004: (as of 25 August 2004)
- 72, 500 Total Accessions
- 90% HSDG
- 67% test score category I-IIIA
- 22% Female (minimum)
- 5,100 Prior Service recruits

Figure 5, 2004 DA Accession Mission (as of: 25 Aug 04, G1 DA)

2.4 Recruiting Process

Army recruiters and civilian contractor recruiters operate similar to traditional sales forces. They generate contacts through multiple mediums with the goal of identifying an interested applicant. The interested applicants are screened physically and mentally to determine eligibility. A qualified applicant chooses a specific Military Occupational Specialty (MOS) and signs the contract at the Military Entrance processing Station (MEPS). Dependent upon the specific job and training date, the new contract either ships directly to training as an "In and For" or is placed into the DEP for accession within the next twelve months. Once a applicant is placed into the DEP, there are requirements for regular contact with the recruiter, physical training, and professional development. The recruiter is responsible for insuring the applicant meets all DEP requirements and ships to basic combat training. Any DEP who fails to ship to basic combat training is classified a DEP loss and must be replaced with a new applicant of similar characteristics. An accessions functional overview, which contains the recruiting process, is depicted in Figure 6.
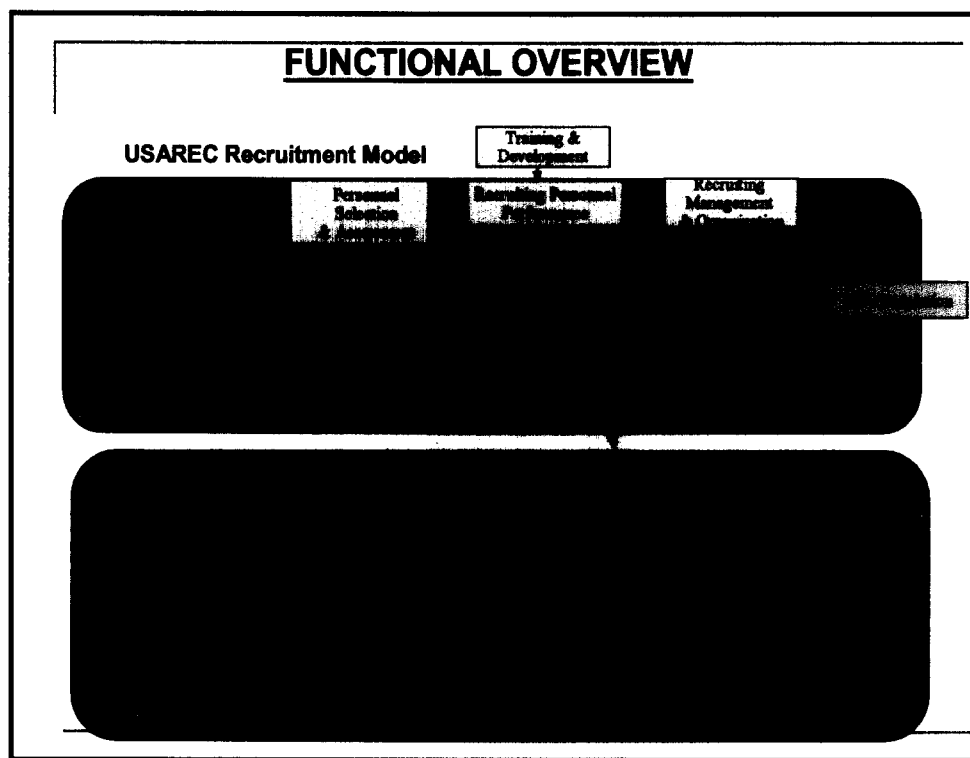
Figure 6, Accessions Functional Overview

3   Problem Definition

3.1   USAREC's Stated Need

"USAREC requires the construction of a strategic and tactical decision support system that optimizes EDEP size by maximizing DEP inventory and quality while minimizing DEP loss, near-term and long-term production shortfalls, and bonus outlays. Research will examine seasonal market changes. Observations will be incorporated into a system that allows a user with minimal training to recommend on a monthly, quarterly and annual basis DEP inventory, and "In and For" levels."

Reviewing this stated need produces two separate requirements. First, construct a decision support system that optimizes EDEP size by maximizing DEP inventory and quality. Second, determine the correct level of "In and For" contracts that should accessed each month.

3.2   Research Methodology

The methodology begins with a thorough literature review (Appendix B) to identify and outline the relevant historical DEP research. The literature review revealed over twenty projects over the last fifteen years and addressed our current problem of managing the DEP and "In and For" levels (Figure 7).

Background Research

Variables Examined
- Unemployment rate
- Time in DEP
- Size of DEP per Recruiter
- Age
- Gender
- Education Level
- AFQT
- Recruiter Attributes

Support Vector machines outperform random forest and logistic regression in determining DEP loss; (Halstead&Brown 2004)

Probability mass functions to forecast DEP loss; (Milch & Whitakewr 1996)

DEP reliability study, 3 months DEP time optimal; (McGurk 1996)

Attrition Summary Statistics FY 1992-1993(Fischl, Blackwell 2000)

Unemployment, DEP length, number of DEPers per recruit affect attrition/logistic regression; (Nelson 1990)

Higher attrition rates associated with less DEP time; (Lukasiewicz, 1995)

Binary Logit Regression for DEP attrition prediction; (Ogren 1999)

Individual analysis of DEP loss is more effective than Battalion level;(Celeste 1986)

Logit Regression model of accession probabilities as a function of time in DEP; (Vales 1994)

1985   1990   1995   2000

Figure 7, DEP Research Literature Review Summary

Our research approach differs from the previous research (Figure 7) in that we chose to systematically capture all the factors in this study using an iterative process known as the Systems Engineering and Management Process (SEMP). The SEMP comprises the remaining portions of the methodology. This process was developed by the Department of Systems Engineering at the United States Military Academy, West Point. The diagram (Figure 8) depicts the flow and iterative nature of the SEMP. The SEMP consists of four phases, shown as circles, and nine total steps which are named within each phase.
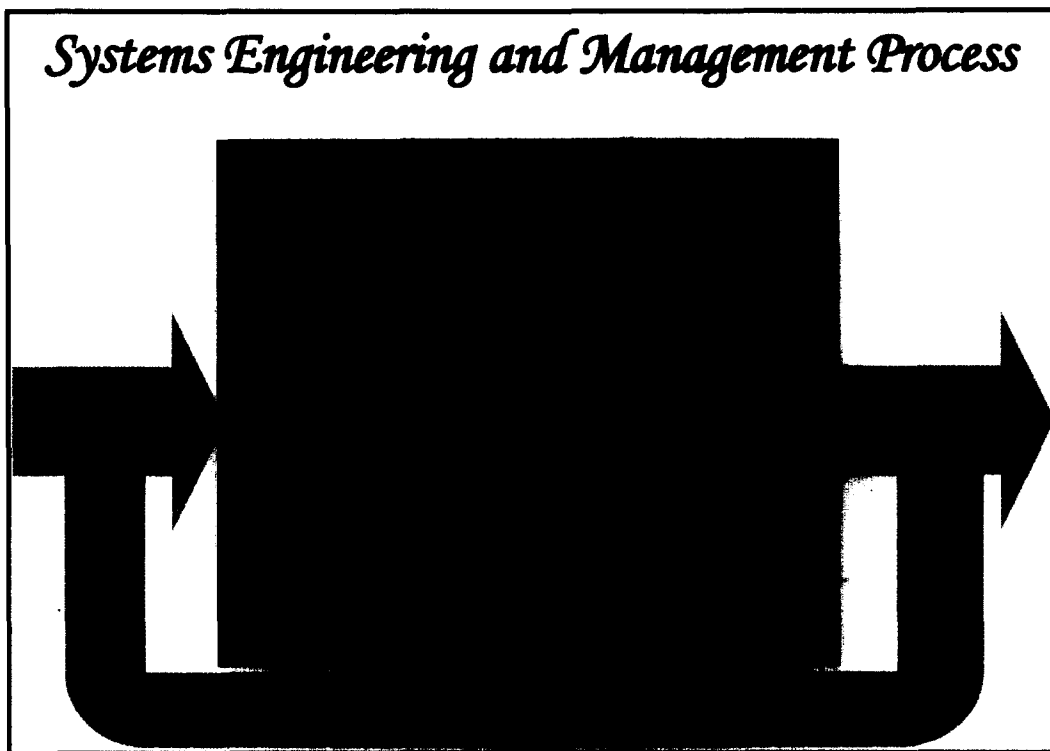
Figure 8, Systems Engineering and Management Process Diagram

The Needs Analysis is the first step in the Problem Definition phase of the SEMP and serves as the basis of understanding the client's engineering design problem. It provides the justification for proceeding further in the design process with the expenditure of time, effort, and other resources. In this project we used extensive Stakeholder Analysis to determine the effective need or true need of USAREC that the system solution should satisfy. In this research we gathered information and opinions from key individuals in the recruiting process. We conducted interviews and workshops with personnel from the Deputy Chief of Staff of Personnel (DCSPER), USAREC staff, recruiting station interviews, and a panel of retired officers with extensive recruiting experience.

Given our dynamic force structure and the Army's current transformation, we believe the SEMP provides USAREC with the most flexible and robust tool for developing an effective DEP decision support system.

4 Proposed "In and For" Solutions

This research examined the policies and use of "In and For" contracts to meet monthly accession goals. Today, USAREC uses "In and For" contracts for a number of purposes to include: offering an incentive for well-qualified and eager contracts, accessing a recruit before his disqualifying thirty-fifth birthday, providing immediate life support for recruits in financial hardship, and providing the commander with flexibility in meeting mission requirements. Overall, the command produces between 100 and 1000 contracts for shipment in the recruited month or "In and For." Contracting and accessing a recruit in the same month drastically reduces the probability of DEP loss and reduces the amount of time a recruiter must spend with a contract before shipping.

Despite these apparent benefits, both prior research and changes in the Army's recruiting environment dictate minimized "In and For" levels. This research recommends:

- The optimal "In and For" level should be set to zero to reduce initial entry attrition rates.

- Allow a flexibility margin of less than 100 "In and For" recruits for the commander each month.

First, two independent studies conducted in the mid-1990s both concluded the optimal level of "In and For" candidates is zero. Michael McGurk in his 1996 study, *Reliability of Soldier's in the Delayed Entry Program,* cited and confirmed a previous study that found three months was the optimal length of time for a recruit to be held in the DEP [15]. The three month DEP maximized the candidate's chances of success at their first duty assignment. Additionally, Chris Lukasiewicz in his 1995 work, *The Delayed Entry Program's Effects on initial Entry Training Attrition,* found a candidate should spend almost six months in the DEP to decease their probability of becoming a DEP loss [13].

Recent changes in the world environment and the Army's transformation process also affected the recommendation for a minimized "In and For" level. As part of the transformation, the Army Chief of Staff, Gen. Peter Schoomaker, is increasing 30,000 troops to the payrolls through fiscal year 2007 [27]. General Cavin believes that

"prequalifying our young soldiers, whether it is the physical fitness assessment or the indoctrination of the warrior ethos during the preparatory training in the Delayed Entry Program" is one of the biggest payoffs that have come from linking the Recruiting Command with training bases. He also believes this increased training in the Delayed Entry Program will reduce overall basic training attrition rates by more than three percent by the end of 2005 [3]. A single DEP loss costs the Army approximately $30,882 [9]. At current DEP loss rates (averaging 20%), the addition of 30,000 new recruits may cost the Army over $37 million from DEP loss alone.

The dynamic and demanding nature of recruiting combined with the transforming Army necessitates an effective and efficient process. Increasing the robustness of the DEP program as General Cavin indicated coupled with minimized "In and For" levels will provide the force with capable soldiers while saving the organization's resources.

5 Optimized DEP

Figure 9 describes the alternatives for a new recruit in October. The flow serves as a template for all other months in the fiscal year. A candidate recruited in October can ship during the same month as an "In and For" or be placed in the DEP system to ship to training in one of the next twelve months. Those candidates in the October DEP for shipment from previous recruiting months can either ship to a training sight or renege their contract, becoming a DEP loss. This researched focused on determining the number and type of contracts to write so Recruiting Command could effectively and efficiently achieve the annual accession mission.

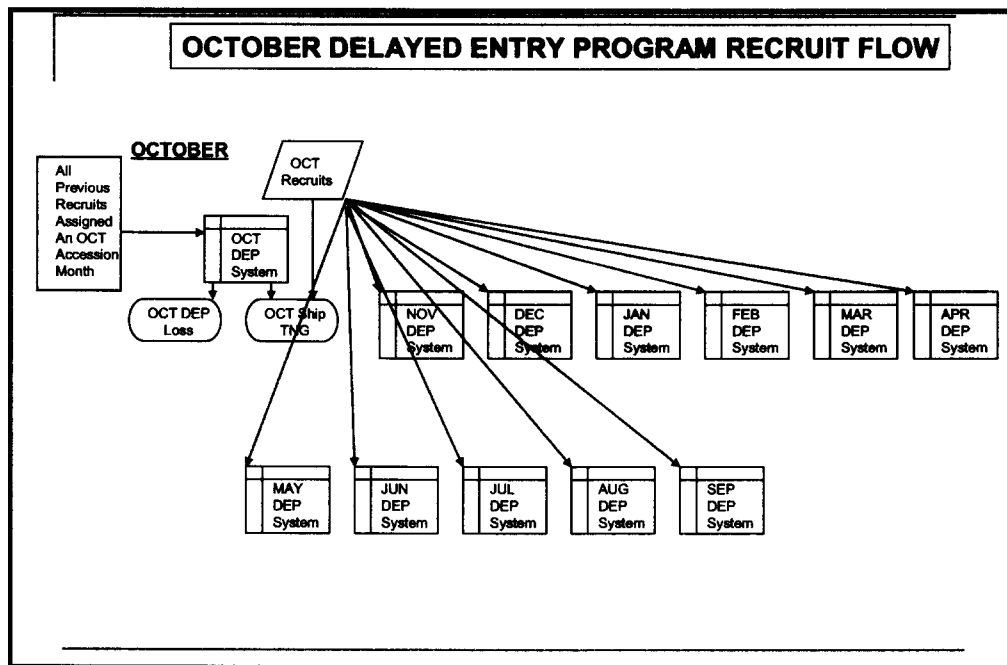**Figure 9, October Contract Flow**

5.1 Solution Methods

A number of alternatives were evaluated to solve this problem. One option includes using Bayesian Belief Network to understand and illustrate the conditional probabilities involved in the DEP program. Unfortunately, there was not enough data to capture the probabilities of each recruit type and accurately identify actual causal relationships.

Dynamic Programming was also a consideration for a solution method. The fundamentals for dynamic programming include:

1) A discrete-time system

2) Independent random parameters

3) Control Constraint

4) Additive Cost

5) Optimization over Control Laws

This research addressed the first four areas for dynamic programming, but wasn't able to accurately identify optimization over Control Laws for the DEP problem. An overview of the methodology and the completed work using Dynamic Programming can be seen in Appendix D.

5.2 Linear Programming

Another method explored and used in this research is linear programming. Our goal was to create a program capable of determining the number of monthly contracts to write for each of the Box types (GMA, GMB, etc.(see Figure 4)). In this case, the optimal number of monthly contracts is the number minimizing overall DEP loss while maintaining all monthly accession requirements.

5.2.1 Model Components

Inputs to the model are:

- i, the box, where $i = 1,\ldots,8$ defined by:

1	2	3	4	5	6	7	8
GMA	GMB	SMA	SMB	GFA	GFB	SFA	SFB

- j, the contract fiscal month (month that recruit is contracted)

- k, the accession fiscal month (month recruit is slated to enter service)

- $P_{i(k-j)}$, the probability of attrition for a recruit in box "i" with "k-j" months in the DEP

- N_{ijk}, the number of contracts to be recruited for mission box "i" in fiscal month "j" for accession in fiscal month "k"

14

The recruit flow model is shown in Figure 10. Beginning at the current DEP System, the applicants can leave the system though attrition (DEP loss) or by shipping to a training base (entering the Army). Recruits are then contracted in fiscal month j. Recruits in fiscal month j can either ship in fiscal month j, or enter into the DEP for fiscal month k.
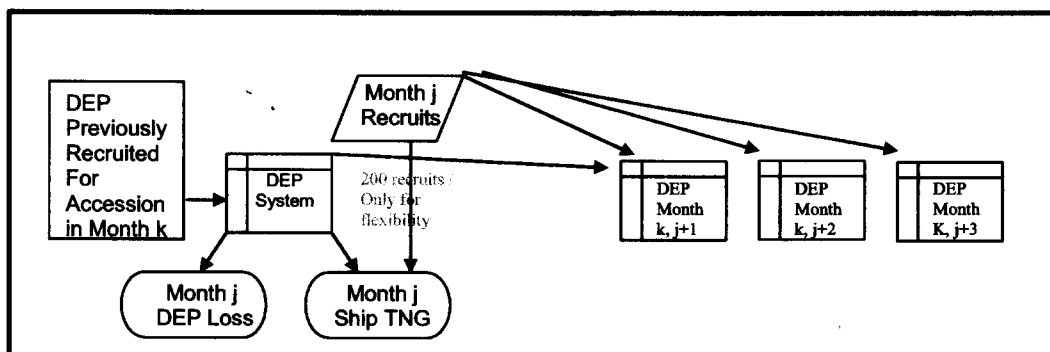
Figure 10, Linear Program Model Diagram

To accomplish this model we used the Army G-1 requirements from the 2004 Mission Memorandum dated 25 August 2003 as our baseline. This memorandum outlines the specific goals and constraints binding USAREC for the year.

Our objective function seeks to minimize the number of recruits lost from the system. Our client, USAREC, specified this would be the best goal so as to minimize the additional work required by the recruiters to replace a DEP loss.

The objective is to:

$$Minimize \sum_{i=1}^{8} \sum_{j=1}^{12} \sum_{k=1}^{24} P_{i,(k-j)} N_{ijk} .$$

Table 1 contains a listing of the input variables and variable descriptions. The first constraints concerning accessions equaling or not exceeding training seats are described in Table 2, which are obtained from the mission memorandum.

15

Table 1, Linear Program Variable Descriptions

Variable	Description
S_k^y	Available training seats for month k in year y
$P_{i(k-j)}$	Probability of attrition for a recruit in box "i" with "k-j" months in the DEP inventory
M^y	Mission for year y (total number of recruits required to access in year y
E	Entry DEP (EDEP) -Percentage of year 2's contracts that must be recruited in year 1
Q	Percentage of next year's msn contracted to access in next year's first quarter
B_i	Proportion of next years Box classification requirements contracted this year
ts^y	Proportion of recruits for year y that must have a test score categry (TSC) of I-IIIA
PS^y	Proportion of total recruits for the year that can be prior service.
lm^y	Minimum monthly proportion of recruits that must access in a month
um^y	Maximum monthly proportion of recruits that must access in a month
ly^y	Minimum yearly proportion of recruits that must access in a year
uy^y	Maximum yearly proportion of recruits that must access in a year
fr^y	Proportion of NPS accesssions that must be female for year y
f^y	Monthly "In and For" mission

Table 2, Monthly Training Seats

Fiscal Month (i)	Calendar Month	2004 Data
1	OCT	6500
2	NOV	6550
3	DEC	0
4	JAN	6950
5	FEB	6900
6	MAR	7200
7	APR	6500
8	MAY	6650
9	JUN	6500
10	JUL	6500
11	AUG	6600
12	SEP	6600

The second constraint is 67% of all FY04 accessions must be test score category (TSC) I-IIIA:

$$\sum_{j=1}^{12}\sum_{k=1}^{24} N_{1jk} + \sum_{j=1}^{12}\sum_{k=1}^{24} N_{3ia} + \sum_{j=1}^{12}\sum_{k=1}^{24} N_{5ia} + \sum_{j=1}^{12}\sum_{k=1}^{24} N_{7jk} \geq ts^y \times \sum_{i=1}^{9}\sum_{j=1}^{12}\sum_{k=1}^{24} N_{ijk}.$$

The third constraint is monthly accessions must be at least 98% of monthly mission:

$$\sum_{i=1}^{9}\sum_{i=1}^{24} N_{bjk} \geq lm^y \times \sum_{i=1}^{9}\sum_{k=1}^{24} N_{bjk}.$$

16

The fourth constraint states monthly accessions must not be greater than 102% of monthly mission:

$$\sum_{i=1}^{9}\sum_{k=1}^{24} N_{bjk} \leq um^y \times \sum_{i=1}^{9}\sum_{k=1}^{24} N_{ijk} \cdot$$

The next constraint places limits on the annual accession mission; annual accession must be at least 100% of the annual mission:

$$\sum_{i=1}^{9}\sum_{j=1}^{12}\sum_{k=1}^{24} N_{ijk} \geq lym^y \times \sum_{i=1}^{9}\sum_{j=1}^{12}\sum_{k=1}^{24} N_{ijk} \cdot$$

The sixth constraint is annual accession must not be greater than 101% of the annual mission:

$$\sum_{i=1}^{9}\sum_{j=1}^{12}\sum_{k=1}^{24} N_{ijk} \leq uyl^y \times \sum_{i=1}^{9}\sum_{j=1}^{12}\sum_{k=1}^{24} N_{ijk} \cdot$$

The seventh constraint concerns NPS females must be at least 22% of all NPS accessions:

$$\sum_{j=1}^{12}\sum_{k=1}^{24} N_{6jk} + \sum_{j=1}^{12}\sum_{k=1}^{24} N_{7jk} + \sum_{j=1}^{12}\sum_{k=1}^{24} N_{8jk} \geq fr^y \times \sum_{i=1}^{9}\sum_{j=1}^{12}\sum_{k=1}^{24} N_{ijk} \cdot$$

The last constraint bounds the EDEP; EDEP must be at least 35% of next year's mission:

$$\sum_{i=1}^{9}\sum_{j=1}^{12}\sum_{k=13}^{24} N_{ijk} \geq E*m^y .$$

The decision variable is:

N_{bia}, the number of contracts to be recruited for mission box "b" in month "i" for accession in month "a" (Example: Number of GMAs to contract in Oct for accession in Nov, Dec, Jan, Feb, Mar......Oct).

5.2.1.1   DEP Loss Probabilities

The probability that a recruit becomes a DEP loss is the topic of many research projects. Currently, John Halstead is investigating the use of neural networks, support vector machines, and random forests to improve upon logistic regression forecasts for DEP loss probabilities [9]. To focus our research on EDEP percentage, we have used the historic DEP attrition rates over a four year period from fiscal year 1999 through 2002

(Table 3). These rates were provided by MAJ Gene Piskator in his work entitled *DEP Attrition Forecasts & DEP Inventory Management* for the United States Accession Command [25].

Table 3, DEP Loss Attrition Percentage Based on Mission Box and Time in DEP

Mission Box		Atrrition Based on Months in DEP											
Box (i)	Box	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
1	GMA	7.5	9.7	13.1	17.2	19.7	22.7	20.1	20.7	21.4	16.6	17.5	21.6
2	GMB	7.9	10.6	13.5	19.4	22.2	19.5	19	13.1	12.6	10.1	6.5	6
3	SMA	31.2	13	14	17.5	19.3	20.8	21.4	23.5	24.7	25.9	29.6	28.8
4	SMB	26.9	12.6	15.9	19.1	21.6	22.7	25	28.3	31.9	32	32.5	32.7
5	GFA	8.8	12.9	18.7	25.2	28.6	31.7	33.3	35.2	36.8	38.7	37.9	43.4
6	GFB	7.5	11.9	18	25.1	27	34.4	36	29.6	39.5	30	6.7	11.8
7	SFA	43.7	13.7	19.6	27	29.3	31.3	34.4	36.7	39.9	42.7	46	47.1
8	SFB	33.2	15.2	21.2	25.6	25.7	30.7	34.5	35.3	28.9	41.1	43.5	38.9
9	Other	7.5	11.6	15.4	18.4	18.3	22.5	22.1	27.3	23.1	25.5	15.5	17.4

5.2.1.2   Assumptions and Limitations

The assumptions and limitations are:

- This model does not consider the individual requirements of Special Forces, linguist, and medical recruitment.

- This model is based on active army recruitment characteristics only.

- This model is based on the assumption that USAREC can continually recruit to mission.

5.2.1.3   Model Screen Shots

This model includes 1152 decision variables in its current form and is implemented it on a Pentium IV computer using Microsoft Excel. This allows us to compare varied EDEPs and include real-time updates with current data. The model is programmed in Excel with the screen shots given by Figure 11, Figure 12, and Figure 13.
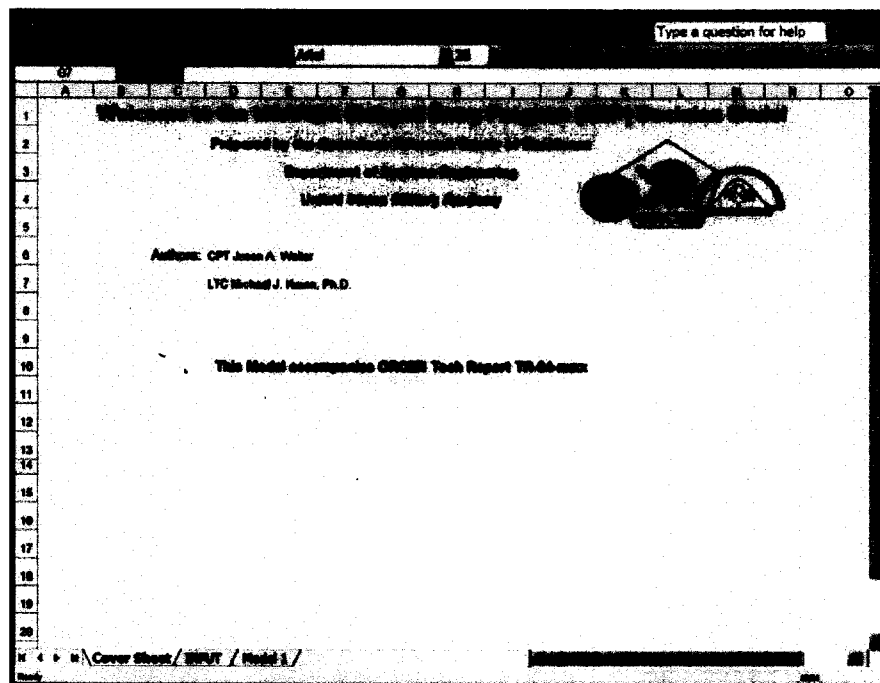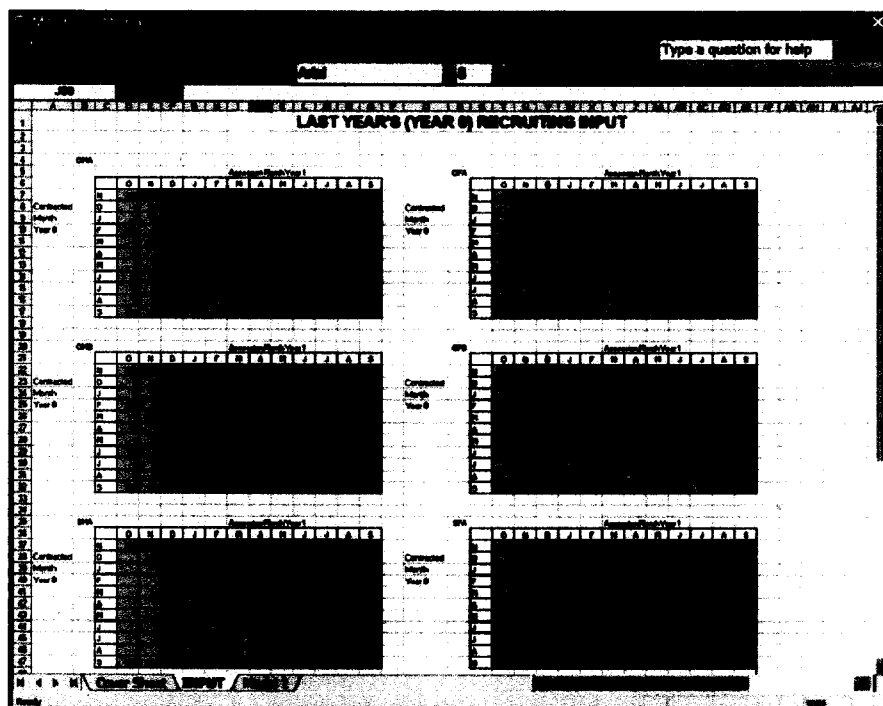
Figure 11, DEP Model Entrance Screen

Figure 12, Model Input Screen

19
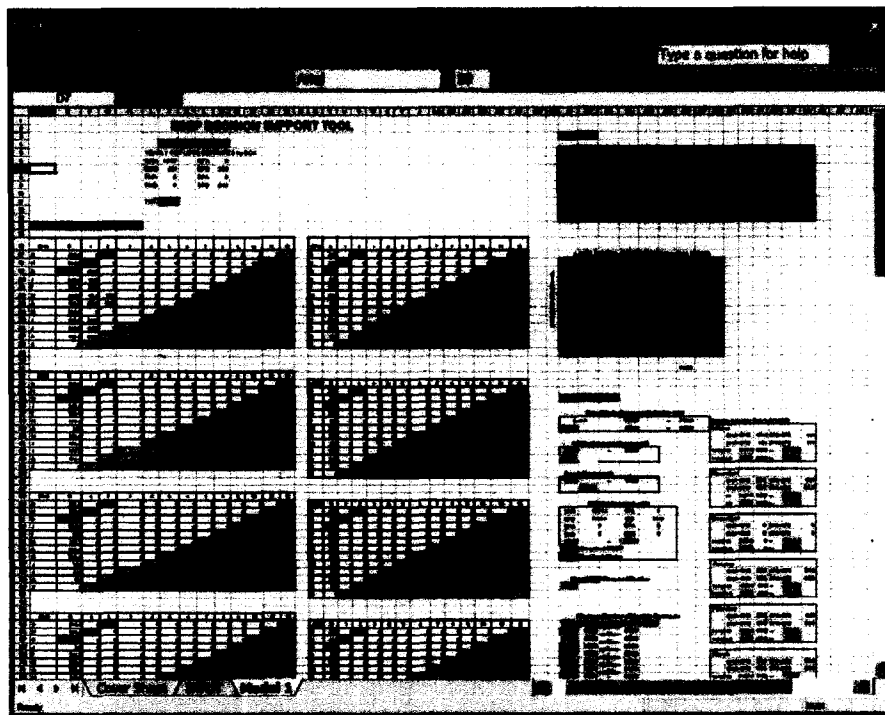
Figure 13, Model Output

5.2.2 Model Output and Results

This DEP Loss model did provide insight to the required EDEP percentage. The required EDEP in this model was varied from requiring all recruits to enter the EDEP (100%) to no EDEP recruits (0%). The intuitive results at these extremes were obvious. Requiring 100% EDEP greatly increased the number of DEP losses and thus the financial loss. What we did not see in our results was a quantifiable difference in DEP losses with an EDEP range between 30% and 40%. The dynamic economic and environmental aspects of recruiting make the minimal DEP loss variations results insignificant and/or inconclusive.

20

6   Conclusions

"In the simplest of times recruiting is a complex business with the casual observer proclaiming that either this factor or another is the "true" driver of success when in reality it is a host of factors working together in concert." General Maxwell Thurman

From our dynamic modeling, we believe an optimum EDEP doesn't exist; based on the Army's current strategy for quality versus quantity, the country's economic state, and other environmental variables yet to be identified. However, a good EDEP range does exist. When the model maintained EDEP levels between 30 and 40%, we predicted better results with little variation between the two percentages.

Determining a raw number through optimization, DP, or other method may not account for recruiting process's dynamic nature and may be inherently inaccurate. Modeling and specifying a specific annual EDEP percentage for USAREC is difficult due to the intricacies and dynamic nature of the recruiting environment. Additionally, we believe given the standards of passing a physical fitness test and instilling the warrior ethos, "In and For" applicants should be minimized.

Further research in this area could involve creating a mission model simulation tracking the process from first contact to shipment to basic combat training. The inputs to this model should include:

- Unemployment Rates (locally, and nationally)
- Number of recruiters
- Accession mission for the fiscal year
- A current year time series forecast of the EDEP
- Current quality marks for USAREC
- Available training seats
- Projected DEP loss figures

These external inputs should be variable to allow for multiple course of action development. The output for this model should include the required write rate for recruiters and the required EDEP for the next fiscal year's mission. A simulation model would assist USAREC in determining the optimal flow of production given set economic and environmental conditions.

References

[1]   Air Force Institute of Technology, Office of Research and consulting (1997), *Style Guide for AFIT Theses and Dissertations*. Wright-Patterson Air Force Base, OH.

[2]   Byrnes, P.E. & Cooke, T. W. (1987), *Recruiting Efficiency and Enlistment Objectives: An Empirical Analysis (CRM 87-181)*, Center for Naval Analyses, Alexandria, VA.

[3]   *Army Times*, (10 May 2004), "The Return to the Draft not Needed, LTG says," Interview with LTG Cavin, USAAC Commander.

[4]   Buning, D., (1991), *US Army's Delayed Entry Program: Attrition Modeling*, Naval Postgraduate School, Monterey, CA.

[5]   Burris, B. (1993), *Missioning with the Minimal Delayed Entry Program (DEP) Loss*, Naval Postgraduate School, Monterey, CA.

[6]   Celesste, J.F., (1984), *Delayed Entry Proram Contracting Cohort Loss Analysis: A Replication Study*, U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

[7]   Celeste, J., (1986), *Research Overview on the U.S. Army's Delayed Entry Program*, U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

[8]   Fischl, M.A. & Blackwell, D. L., (2000), *Attrition in the Army from the Signing of the Enlistment Contract through 180 days of Service*, U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

[9]   Halstead, J.B. & Brown, D.E., (2004), *Improving upon Logistic Regression to predict United States Army Delayed Entry Program (DEP) Losses*, IEEE SEIDS Conference Proceedings, Charlottesville, VA.

[10]   Henry, T., Dice, K. and Davis, J., (2001), *A Decision Support Tool for Determining Army Enlistment Initiatives*, United States Military Academy, West Point, NY.

[11]   Kearl, C. and Nelson A., (1990), *Delayed Entry Program (DEP): A microdata mode*, US Army Research Institute of the Behavioral and Social Sciences, Alexandria, VA.

[12]   Kearl, C. and Nelson, A., (1992), *The Army's Delayed Entry Program*, Armed Forces & Society, Vol. 18, No.2.

[13]   Lukasiewicz, C.E., (1995), *The Delayed Entry Program's Effects on initial Entry Training Attrition*, Naval Postgraduate School, Monterey, CA.

[14]   Manganaris, A. and Phillips,C., (1985), *The Delayed Entry Program – A Policy Analysis*, U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

[15]   McGurk, M., (1996), *Reliability of Soldiers in the Delayed Entry program*, USAREC Library, Fort Knox, KY.

[16]   Milch, P. and Whitaker, L., (Unknown), *Forecasting Future Accessions and Losses from the Delayed Entry Program*.

[17]   Milch,P. and Whitaker,L., (1996), *Forecasting Future Accessions and Losses from the Delayed Entry Program*.

[18] Morey, R., (1987), *Impacts of Size, Composition, and Compactness of the Delayed Entry Pool, Manpower, Personnel, and Training*, R&D Program of the Chief of Naval Research.

[19] Murray, M., (1985), *Navy Delayed Entry Program Attrition Analysis*, Unpublished Master's thesis, Naval Postgraduate School, Monterey, CA.

[20] Nakada, M.K., (1994), *Delayed Entry Program (DEP) Attrition: Recruits, Recruiters, Contracts, and Economics*, Navy Personnel Research and Development Center, San Diego, CA.

[21] Nelson A., (1990), *Delayed Entry Program (DEP) Loss Behavior*, U.S. Army Research Institute of the Behavioral and Social Sciences, Alexandria, VA.

[22] Nelson, A., (1988), *Delayed Entry Program (DEP) Loss Behavior*, U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

[23] Ogren, M., (1999), *Delayed Entry Program Attrition: A Multivariate Analysis*, Naval Postgraduate School, Monterey, CA.

[24] Phillips, C. and Schmitz, E., (1985), *A Microdata Model of Delayed Entry Program (DEP) Behavior*, U.S. Army Research Institute of the Behavioral and Social Sciences, Alexandria, VA.

[25] Piskator, Gene., (Unknown), *DEP Attrition Forecast & DEP Inventory Management.* U.S. Army Accessions Command Presentation, Fort Knox, KY.

[26] Simpson, P.G., (1997), *Optimal Recruiting Strategy to Minimize U.S. Navy Delayed Entry Program (DEP) Attrition*, Naval Postgraduate School, Monterey, CA.

[27] *Feb. 9, Inside the Army*, (Unknown), "The United States Army Transformation Roadmap."

[28] USAREC, (2003), *Statement of Work: Recruiting Market Mission Allocation Mathematical Model.*

[29] Zimmerman, R., Zimmerman, D., and Lathrop, M., (1985), *Study of Factors Related to Army Delayed-Entry Program Attrition*, Naval Postgraduate School, Monterey, CA.

Appendix A: List of Abbreviations

Abbreviation	Description
AFQT	Armed Forces Qualification Test
DA	Department of the Army
DCSPER	Deputy Chief of Staff for Personnel
DEP	Delayed Entry program
DTIC	Defense Technical Information Center
EDEP	Entry Delayed Entry Program (DEP)
G1	Personnel Staff
HSDG	High School Diploma Graduate
MEPS	Military Entry Processing Station
MOS	Military Occupational Skill
NPS	Non Prior Service
ORCEN	Operations Research Center
PS	Prior Service
QMA	Qualified Military Applicants
RAM	Recruiter Allocation Model
SE	Systems Engineering
SEMP	Systems Engineering and Management Process
USAREC	U.S. Army recruiting Command
USMA	United States Military Academy

Appendix B: Literature Review

1) Halstead, J.B. & Brown, D.E., (2004), *Improving upon Logistic Regression to Predict United States Army Delayed Entry Program (DEP) Losses*, IEEE SEIDS Conference Proceedings, Charlottesville, VA.

GOAL: This study improves upon McFadden's previous work with logistic regression for choice analysis.

METHOD: Study investigates the use of neural networks, support vector machines, and random forest as functional approximations to improve upon the results obtained from logistic regression.

RESULTS: For these data, both support vector machines and random forest outperform logistic regression.

RECOMMENDATION: Support vector machines are the best choice model for classifying DEP losses.

2) Henry, T., Dice, K. and Davis, J., (2001), *A Decision Support Tool for Determining Army Enlistment Initiatives*, United States Military Academy, West Point, NY.

GOAL: Create a decision support tool for determining enlisted bonuses.

METHOD: Tool uses a binary integer goal program in Excel solver.

RESULTS: The Enlisted Bonus Distribution Model is a flexible and effective tool to determine incentives while remaining within the recruiting budget.

RECOMMENDATION: This decision tool should be implemented by USAREC as an aid in determining enlistment incentives. The tool is also robust enough to be used as an effective tool in recruiting budget planning.

3) Milch, P. and Whitaker, L., (Unknown), *Forecasting Future Accessions and Losses from the Delayed Entry Program.*

GOAL: Develop a forecasting tool that accurately predicts DEPL loss.

METHOD: Used conditional probabilities of an individual becoming an accession/loss from the DEP given his/her current length of stay using historical records.

RESULTS: This forecasting tool produced viable results when using an entire year, but monthly forecasting results were off due to the seasonality of the DEP population.

RECOMMENDATION: More research needs to be conducted on the seasonality of DEP.

4) Fischl, M.A. & Blackwell, D. L., (2000), *Attrition in the Army from the Signing of the Enlistment Contract through 180 days of Service,* U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

GOAL: Identify factors in attrition for new recruits.

METHOD: Gathered and analyzed summary statistics for the multiple variables to include: AFQT category, waiver, renegotiated contract, gender, race, age, marital status, dependents, enlistment term, U.S. Army area, and MOS.

RESULTS: A summary of 1992-1993 attrition rates for individual variables of interest can be used for comparison and further research..

RECOMMENDATION: None

5) Ogren, M., (1999), *Delayed Entry Program attrition: A Multivariate Analysis*, Naval Postgraduate School, Monterey, CA.

GOAL: Analyze attrition characteristics of the Navy's DEP program.

METHOD: Used binary logit regression to predict DEP attrition with data from all contracts written from FY 1991-FY 1996 in the US Armed Forces.

RESULTS: The findings supported prior research and indicated that attrition was higher for females, high school seniors, personnel with extended time in DEP, and personnel with no dependents. The current reasons for male DEP loss are apathy/personal problems (37.9%), medical (14.1%) and moral (12.8%). Women DEP loss reasons include apathy/personal problems (49.3%), medical (3.6%), and pregnancy (13.3%).

RECOMMENDATION: Results from this study should be used by USAREC to improve the efficiency of the DEP process.

6) Simpson, P.G., (1997), *Optimal Recruiting Strategy to Minimize U.S. Navy Delayed Entry Program (DEP) Attrition*, Naval Postgraduate School, Monterey, CA.

GOAL: This thesis develops an optimization-based model to assist the Navy Recruiting Command in placing nuclear power field recruits in the Delayed Entry Program (DEP).

METHOD: Formulated as a nonlinear program that minimizes relative recruiting costs weighted with respect to the desired recruit category. Integral to the model are estimates of DEP loss probability for the various combinations of recruit categories and DEP lengths.

RESULTS: This research concludes that the annual new contract objective (NCO) does not support the successful attainment of the accession goal

RECOMMENDATION: None

7) McGurk, M., (1996), *Reliability of Soldiers in the Delayed Entry Program*, USAREC Library, Fort Knox, KY.

GOAL: Determine the effects of individual attributes on candidate DEP reliability.

METHOD: Reviewed USAREC historical files and provided summary statistics

RESULTS: Discovered, using data from 1996, the lowest likelihood candidates for DEP loss would be young, black, males with dependent children and a high school diploma. The author also commented on the Marine Corp study, which found three months were required in DEP to increase the probability of successfully completing their first duty assignment. While anytime over three months in the DEP provided little return for the associated costs.

RECOMMENDATION: DEP time should be limited to three months for all candidates.

8) Milch, P. and Whitaker, L., (1996), *Forecasting Future Accessions and Losses from the Delayed Entry Program.*

GOAL: Forecast future accessions and losses by examining all of the DEP records from 1988 to 1995.

METHOD: Used probability mass functions to accurately forecast yearly data, but was unable to forecast on a monthly basis.

RESULTS: Probability mass functions accurately predicted DEP loss propensity on a monthly basis, but failed to accurately predict annual DEP loss probabilities.

RECOMMENDATION: Recommendation is to segment the data into quarterly or monthly portions for analysis.

9) Lukasiewicz, C.E., (1995), *The Delayed Entry Program's Effects on Initial Entry Training Attrition,* Naval Postgraduate School, Monterey, CA.

GOAL: Determine the effects the DEP program has on first term attrition.

METHOD: Examined the USAREC mini-master data files from 1987-1993 and computed summary statistics.

RESULTS: Found most groups having higher attrition rates tend to spend less time in the DEP. The lowest initial entry (IET) attrition rates were found for those who spent six to eight months in the DEP. Additionally, AFQT score, gender, and education level explain more about predicting IET attrition than does the time and individual spends in the Delayed Entry program.

RECOMMENDATION: Results from this study should be used by USAREC to improve the efficiency of the DEP process.

10) Nakada, M.K., (1994), Delayed *Entry Program (DEP) Attrition: Recruits, Recruiters, Contracts, and Economics*, Navy Personnel Research and Development Center, San Diego, CA.

GOAL: Examined and attempted to quantify the impact on DEP attrition from four variables: recruit characteristics, DEP contract specifications, recruiter characteristics and economic factors.

METHOD: Regression analysis.

RESULTS: Individual attributes of the recruit and DEP contract variables are highly significant factors impacting attrition. The only recruiter variable that produced significant findings was recruiter rank. Individuals recruited by recruiters with rank E7 and above were less likely to attrite. Recruits from areas of higher unemployment rates were less likely to attrite. Also, as the average number of recruits in DEP per recruiter increases so does the attrition rate.

RECOMMENDATION: Study should be used by naval recruiters to focus their efforts on candidates with higher loss probabilities.

11) Burris, B., (1993), *Missioning with the Minimal Delayed Entry Program (DEP) Loss*, Naval Postgraduate School, Monterey, CA.

GOAL: Formulates the problem of setting monthly recruiting missions as an optimization problem with the objective of minimizing the number of DEP loss.

METHOD: Uses these probabilities in a General Algebraic Modeling System (GAMS) to determine monthly missions. Data used for this study is from 1988 to 1992.

RESULTS: Study identified 22 separate recruit classifications and accurately determined DEP loss probability based on these attributes.

RECOMMENDATION: Future DEP inventory management should incorporate these findings to predict loss.

12) Buning, D., (1991), *US Army's Delayed Entry Program: Attrition Modeling*, Naval Postgraduate School, Monterey, CA.

GOAL: Develop a model that accurately predicts DEP loss.

METHOD: Models individual DEP loss utilizing multivariate dichotomous logistic regression. The research used all non prior service contracts signed in FY 1986 to FY 1990.

RESULTS: Identified characteristics that increased a specific candidate's likelihood of becoming a DEP loss.

RECOMMENDATION: Provided a quantitative model to assist recruiters in further identifying those candidates who are at high risk for becoming a DEP loss.

13) Nelson A., (1990), *Delayed Entry Program (DEP) Loss Behavior*, US Army Research Institute of the Behavioral and Social Sciences, Alexandria, VA.

GOAL: Examine the contributions of various factors to overall DEP loss probability.

METHOD: Used a time series model on data recruit data from 1984-1987 and also used logistic regression to determine that DEP length and age were positively related to DEP loss.

RESULTS: Showed that unemployment rate, average DEP length and number of individuals in DEP per recruiter were all significant factors in determining DEP loss rates.

RECOMMENDATION: Results from this study should be used by USAREC to improve the efficiency of the DEP process.

14) Kearl, C. and Nelson A., (1990), *Delayed Entry Program (DEP): A Micro-data Model*, US Army Research Institute of the Behavioral and Social Sciences, Alexandria, VA.

GOAL: Was an extension of the Nelson (1988) study to determine DEP behavior.

METHOD: Using binary logistic regression, estimated the effects of personal characteristics (age, gender, race, dependent status, high school status, and AFQT score, recruiting tools DEP length, Army College Fund, enlistment bonus, and term of enlistment, and economic factors (unemployment rate, relative military/civiliam wages on DEP loss during FY 1986-1987.

RESULTS: Results indicated that personal characteristics of DEP recruits had the largest influence on DEP loss. High risk candidates were likely to be older, female, white, without dependents, and without a high school diploma.

RECOMMENDATION: None

15) Nelson, A., (1988), *Delayed Entry Program(DEP) Loss Behavior*, U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

GOAL: Identify significant variables in DEP loss behavior.

METHOD: Used USAREC DEP data from 1984-1987.

RESULTS: Found the youth unemployment rate, average DEP length, and size of the DEP per recruiter have significant influence on the DEP loss rate trends in the time series model. The unemployment rate was the single most substantial factor influencing the DEP loss rate.

RECOMMENDATION: None

16) Celeste, J., (1986), *Research Overview on the U.S. Army's Delayed Entry Program*, U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

RESULTS: Complete a detailed literature review of research on the Delayed Entry Program.

17) Phillips, C. and Schmitz, E., (1985), *A Micro-data Model of Delayed Entry Program (DEP) Behavior*, US Army Research Institute of the Behavioral and Social Sciences, Alexandria, VA.

GOAL: Determine the effects that individual characteristics have on DEP loss.

METHOD: Used maximum likelihood logistic regression to model the effects of several variables on the DEP loss behavior.

RESULTS: Results indicated that DEP length, gender, and age were the strongest predictors of DEP loss.

RECOMMENDATION: Suggests that recruiters could use this data to target individuals at high risk for DEP loss and increase monitoring during this period.

18) Murray, M., (1985), *Navy Delayed Entry Program Attrition Analysis*, Unpublished Master's thesis, Naval Postgraduate School, Monterey, CA.

GOAL: Predict Naval recruit attrition tendencies.

METHOD: Used logistic regression to predict DEP attrition with contracts signed in FY 1980 and FY 1983. The study used the following predictors: size of DEP, months in DEP, recruiting district, age, mental group, race, and educational level.

RESULTS: Previous predictors except race significantly predicted DEP loss.

RECOMMENDATION: None

19) Zimmerman, R., Zimmerman, D., and Lathrop, M., (1985), *Study of Factors Related to Army Delayed-Entry Program Attrition*, Naval Postgraduate School, Monterey, CA.

GOAL: Identify personal factors related to DEP loss.

METHOD: A telephone survey sample of 1,000 was drawn from the Army enlistees participating in the DEP for FY 1984.

RESULTS: Found the five highest reasons for becoming a DEP loss were: dissatisfied with occupational assignments, decided to attend school, perceived availability of better jobs, change in attitude towards the Army, and found a civilian job.

RECOMMENDATION: The information collected in this study can be useful in mitigating the effects of DEP loss on recruiting.

20) Manganaris, A. and Phillips,C., (1985), *The Delayed Entry Program – A Policy Analysis,*. U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

GOAL: Analyze the effects of existing policies on the DEP program.

RESULTS: DEP participation leads to lower first-term attrition and the rates are MOS-specific. Male I-IIIA non-graduates ere more expensive than IIIB high school graduates. Minimizing DEP lengths aids recruiting it can lead to higher attrition and higher overall costs.

RECOMMENDATION: The DEP policy should be MOS-specific. Consider minimizing total loss vs. total cost for highly sought after personnel (I-IIIA high school graduates).

21) Celesste, J.F. (1984) *Delayed Entry Proram Contracting Cohort Loss Analysis: A Replication Study.* U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

GOAL: Identify significant factors contributing to DEP loss.

METHOD: Followed contracts from 1981-1983 and found a strong positive correlation between time in DEP and DEP loss rate.

RESULTS: Male high school seniors or graduates experienced a lower rate of DEP loss. Female applicants experienced loss rates more than twice the rates of males across the three contracting periods.

RECOMMENDATION: Results from this study can be used to improve the efficiency of the DEP process.

Appendix C: Why the 35% EDEP?

INFORMATION PAPER

DAPE-MPA-RP
22 January 2002

SUBJECT: Army Entry Delayed Entry Program (DEP) Goal

1. PURPOSE: To provide information on the Army's Entry Delayed Entry Program
(DEP) goal – the volume of contracts the Army wants in the DEP at the beginning of the
fiscal year.

2. FACTS.

    a. The Army's stated entry DEP goal is 35 percent of the fiscal year accession
mission. This is intended to perpetuate the ability to have the following quarter's
accession mission in the DEP at all times. This allows efficient placement of contracts
against Army MOS requirements and efficient training seat utilization. The entry DEP is
usually the lowest volume DEP during a year.

    b. Figure 1 shows the entry DEP level for recent years. With the exception of
FY93, during each year that the entry DEP was less than 35 percent of the final accession
mission for the year the Army either missed the accession mission or had to accept lower
quality to make it, as well as aggravated Military Occupational Specialty (MOS)
shortages due to misaligned accessions and seasonal shortfalls. In FY93, the Army
would have failed its initial mission but was saved by a mission reduction of 5,700 as part
of the draw down.
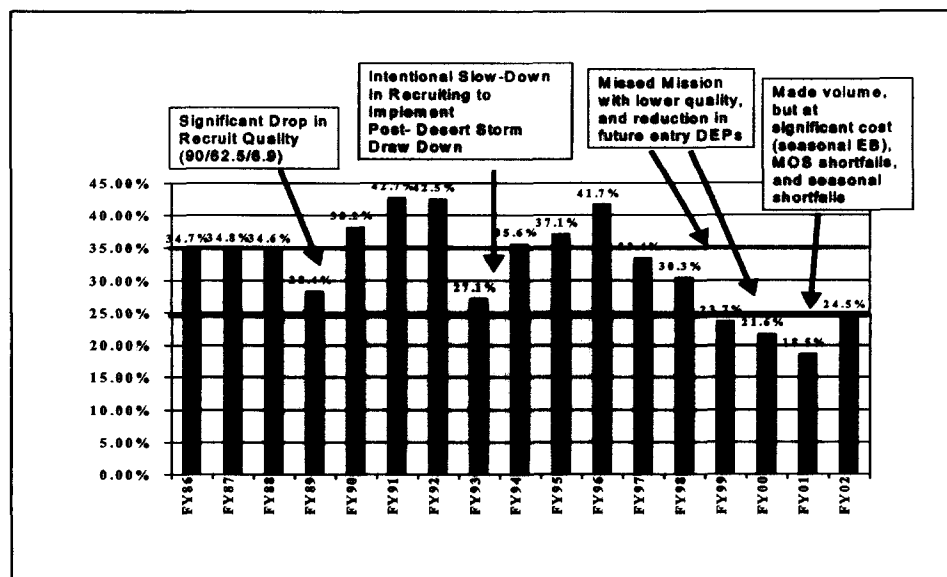
DA Figure 1, Entry DEP as a percentage of final accession mission

34

c. Table 1 shows the entry DEP volume and percent of DEP distribution by quarter for post draw down years. Table 2 shows the accessions achieved by quarter and the percent of annual mission achieved by quarter. The goal is to achieve an accession flow of 19 percent 1st Quarter, 25 percent 2d Quarter, 25 percent 3d Quarter, and 31 percent fourth quarter to maximize the efficiency of the training base and to minimize the operating strength deviation during the year, thus maximizing readiness from an accession standpoint. As shown in Table 2, the only post draw down year that we have come close to this accession distribution was in FY97, when the entry DEP was close to 35 percent of the final accession mission. Note that the percentage distribution of the entry DEP has shifted dramatically away from the 1st Quarter in spite of efforts to minimize the 4th Quarter DEP in order to maximize the 1st Quarter DEP. The reason is that as the DEP declined, with resulting 2d and 3d Quarter accession failures, the Army was forced to recruit heavily in-and-for the 4th Quarter. This prevented many 4th Quarter contracts from feeding the 1st Quarter DEP. Meanwhile, a limited number of new High School Seniors will always contract during the 4th Quarter to access the following 4th Quarter unless we actively turn them away. The cyclical impact is a low 4th Quarter DEP the following year, leading to more in-and-for the Quarter contracting the following year, continuing to draw down the subsequent year's 1st Quarter DEP.

DA Table 1, Distribution of Entry DEP

Distribution of DEP (Volume of DEP in Each Quarter)

	15,195	8,592	6,461	8,849	6,399	10,939
	3,185	1,608	1,129	1,048	1,240	1,580
	5,160	5,930	4,325	3,203	2,948	3,325
	4,476	4,851	5,814	4,151	3,976	3,477
	28,016	20,981	17,729	17,251	14,563	19,321
	82,000	72,550	74,500	80,000	78,950	79,000
	34.2%	28.9%	23.8%	21.6%	18.4%	24.5%

Distribution of DEP (Percent of DEP in Each Quarter)

	54.2%	41.0%	36.4%	51.3%	43.9%	56.6%
	11.4%	7.7%	6.4%	6.1%	8.5%	8.2%
	18.4%	28.3%	24.4%	18.6%	20.2%	17.2%
	16.0%	23.1%	32.8%	24.1%	27.3%	18.0%

DA Table 2, Accessions

Accessions Achieved by Quarter

	16,028	10,578	10,074	13,045	13,271
	19,022	16,913	16,039	20,435	20,159
	18,330	16,374	15,774	15,974	17,775
	28,707	27,888	26,322	30,659	24,650
	82,087	71,753	68,209	80,113	75,855
	82,000	72,550	74,500	80,000	75,800
	100.1%	98.9%	91.6%	100.1%	100.1%

Percent of Mission Achieved in Each Quarter

	19.5%	14.6%	13.5%	16.3%	17.5%
	23.2%	23.3%	21.5%	25.5%	26.6%
	22.4%	22.6%	21.2%	20.0%	23.4%
	35.0%	38.4%	35.3%	38.3%	32.5%

d. To break this cyclical down spiral requires that we recruit about one Quarter in front of ourselves. Table 3 shows the gross contracts produced each quarter. Note that 2d and 4th Quarter are seasonally high production quarters, while 1st and 3d Quarters are seasonally low production quarters. With the "even flow" quarterly accession distribution of 19/25/25/31, and the seasonally reduced contract production of the 1st and 3d Quarter, this requires that June-September must have a number of contracts already placed in the months prior to the in-the-year contracting cycle. This is provided by the previous summer Senior contracts, amounting to greater than 10,000 contracts if we actively recruit for them. These contracts habitually experience increased DEP attrition, but even at 35% attrition they provide over 7,000 summer accessions. Combined with in-the-year contracting, this allows a large number of 4th Quarter contracts to go towards the following year's 1st Quarter DEP, perpetuating the success.

DA Table 3, Volume Gross Contracts

Volume Gross Contracts Achieved by Quarter

	20,274	22,088	19,610	21,288	21,925
	23,037	22,709	22,833	23,865	23,503
	22,852	19,415	18,285	22,402	22,578
	28,745	22,093	23,821	26,256	26,323
	94,908	86,305	84,549	93,811	94,329

Percent of Volume Gross Contracts Achieved in Each Quarter

	21.4%	25.6%	23.2%	22.7%	23.2%
	24.3%	26.3%	27.0%	25.4%	24.9%
	24.1%	22.5%	21.6%	23.9%	23.9%
	30.3%	25.6%	28.2%	28.0%	27.9%

MAJ Jessup / 614-7807

Appendix D: Dynamic Programming

1) VARIABLES

M = Mission; total number of recruits required for year

$EDEP$ = Percentage of recruits that must be scheduled for accession in the next fiscal year prior to the start of the year. (25% to 40% of yearly mission)

a = Month recruit is accessed into service (a = 1,...,23)

D_a = Number of recruits in DEP for accession in month a (STATE OF THE SYSTEM)

where $D_a = \sum_{b=1}^{9}\sum_{i=1}^{12} N_{bia}$

S_a = Number of recruits to ship to available training seats for month a (DEMAND VARIABLE)

$P_{b,(a-i)}$ = Probability of attrition for a recruit in box b with $a-i$ months in the DEP inventory

2) DECISION VARIABLES

N_{bia} = Number of contracts to be recruited for mission box b in month i for accession in month a
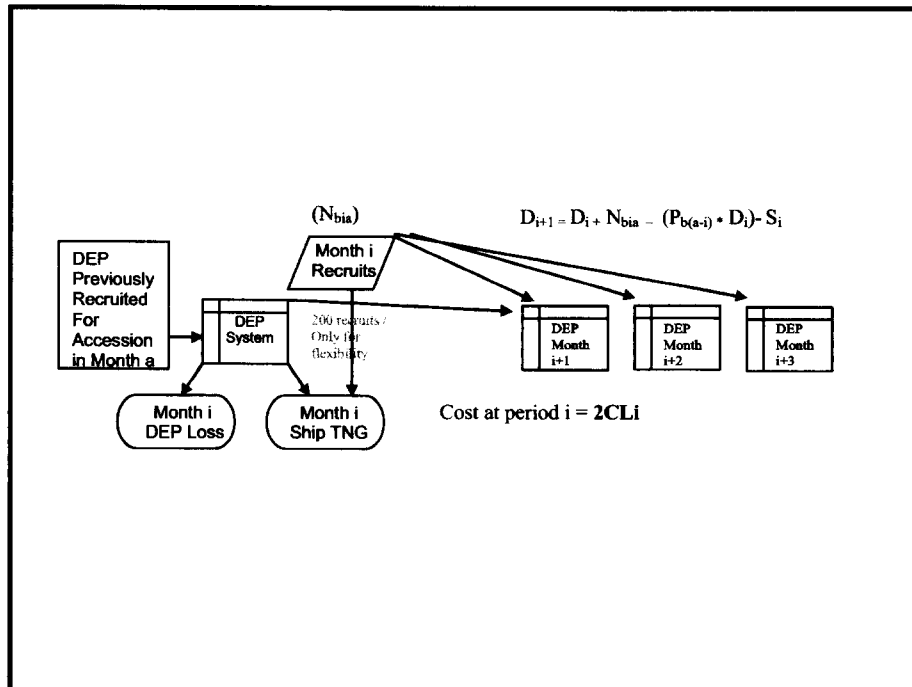
Appendix D Figure 1, Dynamic Programming of DEP

3) Dynamic Program

a. Discrete time system

$$D_{i+1} = f_i(N_{bia}, P_{b(a-i)}, S_i),$$

where, $f_i = N_{bia} - (P_{b(a-i)} * D_i) - S_i$

and L_{bi} = Number of box type b to become a DEP loss in month i

b. Independent random parameters

L_{bi} is a probability distribution based on D_i and time $(a-i)$

c. Control Constraints

   i. Recruits can spend a maximum of 12 months in the DEP: $(a-i) \le 12$

   ii. 67% of al FY04 accession must be TSC I-IIIA:

$$\sum_{i=1}^{12}\sum_{a=1}^{23} N_{1ia} + \sum_{i=1}^{12}\sum_{a=1}^{23} N_{3ia} + \sum_{i=1}^{12}\sum_{a=1}^{23} N_{5ia} + \sum_{i=1}^{12}\sum_{a=1}^{23} N_{7ia} \ge 0.67 \times \sum_{b=1}^{9}\sum_{i=1}^{12}\sum_{a=1}^{23} N_{bia}$$

   iii. Monthly accessions must be within 98 to 102% of monthly mission:

$$0.98 \times \sum_{b=1}^{9}\sum_{a=1}^{23} N_{bia} \ge S_i \ge 1.02 \times \sum_{b=1}^{9}\sum_{a=1}^{23} N_{bia}$$

   iv. Annual accession mission must be within 100 to 101% of annual mission:

$$\sum_{b=1}^{9}\sum_{i=1}^{12}\sum_{a=1}^{23} N_{bia} \ge S_i \ge 1.01 \times \sum_{b=1}^{9}\sum_{i=1}^{12}\sum_{a=1}^{23} N_{bia}$$

   v. NPS females must be at least 22% of al NPS accessions:

$$\sum_{i=1}^{12}\sum_{a=1}^{23} N_{5ia} + \sum_{i=1}^{12}\sum_{a=1}^{23} N_{6ia} + \sum_{i=1}^{12}\sum_{a=1}^{23} N_{7ia} + \sum_{i=1}^{12}\sum_{a=1}^{23} N_{8ia} \ge 0.22 \times \sum_{b=1}^{9}\sum_{i=1}^{12}\sum_{a=1}^{23} N_{bia}$$

d. Additive Cost

C = Total cost to fill training slots (recruiting/procurement costs) in period i; where C is cost per recruit = $15,441 [9]

$2CL_i$ = cost per DEP Loss = $30,882

The expected cost over N periods is $E\left[\sum_{i=0}^{n-1} 2CL_i\right]$

The initial procurement cost C is a sunk cost to prevent double counting

e. Optimization over control laws: objective is to minimize cost by properly choosing the correct N_{bia} for each possible value of D_a

38

Distribution List

The list indicates the complete mailing address of the individuals and organizations receiving copies of the report and the number of copies received. Due to the Privacy Act, only use business addresses; no personal home addresses. Distribution lists provide a permanent record of initial distribution. The distribution information will include the following entries:

Author(s)	Department of Systems Engineering Mahan Hall West Point, NY 10996	2
Client	USAAC CAR 1307 Third Ave., Fort Knox, KY 40121	4
Dean, USMA	Office of the Dean Building 600 West Point, NY 10996	1
Defense Technical Information Center (DTIC)	ATTN: DTIC-O Defense Technical Information Center 8725 John J. Kingman Rd, Suite 0944 Fort Belvoir, VA 22060-6218	1
Department Head-DSE	Department of Systems Engineering Mahan Hall West Point, NY 10996	1
ORCEN	Department of Systems Engineering Mahan Hall West Point, NY 10996	5
ORCEN Director	Department of Systems Engineering Mahan Hall West Point, NY 10996	1
USMA Library	USMA Library Bldg 757 West Point, NY 10996	1

REPORT DOCUMENTATION PAGE – SF298

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE		3. DATES COVERED *(From - To)*
August 2005	Technical Report		1/04 – 6/04

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
US Army Delayed Entry Program Optimization Model	
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
MAJ Jason Wolter, LTC Michael J. Kwinn, Jr., LTC John Halstead	DSE-R-0428
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Operations Research Center of Excellence Department of Systems Eng. Bldg #752-Mahan Hall-Rm 306 West Point, NY 10996	DSE-TR-0428

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
USAAC CAR 1307 Third Ave. Fort Knox, KY 40121	
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
DISTRIBUTION A - unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
U.S. Army Recruiting Command (USAREC) requires a robust and predictive system that will optimize their monthly and annual percentage of recruits in the Delayed Entry Program (DEP). This optimization system must also consider the dynamic nature of "In and For" recruits, those recruits who are contracted and accessed in the same month. The DEP is a direct reflection of current economic factors (unemployment), eligible youth, DoD marketing/advertising efforts, and the resources available to recruiters. This research integrates previous research concepts to help build a predictive management system that will assist in minimizing the impacts of DEP loss. Additionally, this research examined the use of "In and For" contracts given historic research and new policy changes. Ultimately, this research allows USAREC to increase efficiency in meeting accession requirements, and provide a tactical tool for planning.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF: Unclassified			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON MAJ Jason Wolter
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified	None	40	19b. TELEPHONE NUMBER *(include area code)* 845-938-5897